The Human Factor in Simulated Emergency Evacuations of Aircraft Cabins: Psychological and Physical Aspects. Neal S. Latman, Ph.D., NSL Associates, 513 Bowie St., Borger, TX, USA 79007.

ABSTRACT:

The three factors which influence a safe and effective emergency evacuation of an aircraft cabin are the aircraft, the environment, and human factors. Although least examined, the human factors are, perhaps, the most complex and important. The goal of this work is the reification of the abstract ideas about the importance of human factors into concrete, useable methods, instruments, and data. If the reasons for appropriate and inappropriate evacuation behavior are understood, we might be able to activate passengers to appropriate behavior and, thereby, increase the safety and efficacy of emergency evacuations. This is the initial report of the influence personality and physical traits might have on emergency evacuation behavior. This report focuses on Aseat-climbing@ behavior as an example of the utility of this approach. We conclude that it might be possible to improve the safety and efficacy of emergency evacuations of aircraft cabins by evaluating the human factors aspects of evacuation behavior. The results of the evaluations could be used to re-engineer aircraft and environmental factors to activate passengers to appropriate and beneficial behavior.

Introduction:

The goal of an emergency evacuation is the safe and effective evacuation of all of the aircraft passengers and crew. For the purposes of study and experimentation, we have divided the factors that impact on the safe and efficacious evacuation as follows:

1.) Aircraft
   - Design
   - Construction Materials
   - Configuration
   - Etc.

2.) Environment
   - Lighting
   - Litter
   - Smoke
   - Fire
   - Weather
   - Etc.

3.) Human Factors
   - Personality
   - Behavior
   - Physical Characteristics
   - Perceptions
   - Motivation
   - Cultural
   - Etc.

The purpose of this paper is to discuss some of the recent experimentation by Transport Canada Civil Aviation on the involvement of the human factors in aircraft cabin evacuations.

One problem in simulated emergency aircraft cabin evacuation is the limited ability to follow individuals during an evacuation. Historically this has been done by video taping the subjects wearing numbered vests during the simulated emergency evacuations. This procedure is limited by conditions of crowding, lighting, smoke, etc. Transport Canada Civil Aviation has recently been working on an RF signaling device that can provide automatic recording of the location of any subject during any point in the evacuation procedure. Used alone or in combination with other devices, this novel use of technology can dramatically increase our ability to evaluate behavior during experimental evacuation conditions.

At its most basic level, the problems of a safe and effective evacuation are the problems of human behavior. The purpose of this work was to view emergency evacuations from a perspective that is different from the classical approach. It was to look at factors that effect these evacuations from a human factors point of view.

Short History:

An increased interest in the human factors aspect of simulated emergency cabin evacuation was beginning to be evident at the 1995 International Conference on Cabin Safety Research in Atlantic City, USA.

At that meeting Kirke Comstock, United Airlines, noted that Avalue added research@ will come more from human performance research. He suggested that we pursue Aactivating passengers to appropriate behavior.@

James Likes, Boeing Commercial Airplane Group, suggested that the key element is to discover and use the best and most efficient procedures for guiding evacuating passengers from their seats to the ground.

Helen Muir, Cranfield University, listed four factors which could influence survival in an aircraft accident as: 1) configuration of aircraft cabin, 2) environmental, 3) procedural, and 4) behavior.

In a slight, but very significant way, Romi Singh, Aviation Research Corp, provided a modified and expanded list of factors that he thought could effect emergency evacuations: 1) static elements (aircraft), 2) dynamic elements (environment), 3) mobile elements (people), and 4) behavioral elements. In this discussion Singh explained that behavior was a function of many other variables, including psychological variables.

At the same meeting Edwin Galea, University of Greenwich, noted that of the factors which influence an evacuation, behavior was the most complex. He posed several specific questions about behavior that needed to be answered to understand overall escape strategy and local or immediate behavior responses. He recommended that a high priority be given to human factor data collection.

Immediate Goal:

Our immediate goal in the work presented here was the reification of the abstract ideas about the importance of human factors and behavior into concrete, useable methods, instruments, and data.

The Work Reported Here:

This work was initiated and designed by Transport Canada Civil Aviation (TCCA). The experimentation and data collection was conducted by the Department of Applied Psychology of Cranfield University under contract with TCCA. NSL Associates provided experimental design and data analysis consultation under contract with TCCA. The Personality and Physical Profiles were developed by NSL Associates in collaboration with TCCA. The validity and reliability of the personality profiles were established by JonDel, Inc. under a separate contract with TCCA.

Caveats: The three main factors which effect the safety and efficacy of aircraft cabin evacuations (aircraft, environment, and human factors) interact in a complex manner. A change in any one factor can effect the other factors. The data reported herein was collected under certain specific experimental conditions and are not intended to represent final, universal answers for all emergency (simulated or real) evacuations. Rather, it is to illustrate methods and instruments that are being developed by TCCA and the type of data and its potential use.

The Theory:

The initiation of this work was based on the concept that behavior, such as simulated emergency aircraft cabin evacuations, can be understood, to a greater or lesser degree. If the reasons for appropriate and inappropriate evacuation behavior are understood, the evacuation situation might be changed (re-engineered) to evoke the most appropriate behavior and minimize the probability of inappropriate behavior. We might be able to activate passengers to appropriate behavior and, thereby, increase the safety and efficacy of the evacuation.

Two human factors are examined in this initial report of experimental work: personality and physical characteristics. Personality traits are examined to develop an understanding of the psychodynamics of evacuation behaviors. The physical traits are examined to determine physical limitation and capabilities of the individuals to engage in various evacuation behaviors.

Personality Traits:

A list of 14 personality characteristics was developed that, it was thought, might impact human behavior during an aircraft cabin evacuation. In addition, the list only included those characteristics that, it was thought, might provide a psychodynamic understanding of the behavior. The personality traits included the following:

Anxiety	Dominance
Confidence	Assertiveness
Insecurity	Leadership
Restlessness	Mental Agility
Fearfulness	Goal Directed
Risk Taker	Decisiveness
Boldness	Self Consciousness

TCCA Personality Profiles:

Personality traits are, however, abstract concepts. To use them, these concepts must be converted to concrete, measurable variables. To convert the abstract concepts into measurable variables, we developed a questionnaire that could be administered in 5 minutes or less. This

questionnaire was administered to subjects prior to their participation in simulated emergency evacuations of aircraft cabins. Subject behavior during the evacuation experiment was correlated to their personality traits as reified by the TCCA personality profile questionnaire.

Evaluation of TCCA Personality Profile, Version 1:

The questionnaire was evaluated for reliability and validity by JonDel, Inc.

Reliability: Reliability was evaluated by three measures: internal consistency, questionnaire stability, and personality trait stability.

1.) Internal consistency was determined by Chronbach=s coefficient alpha, which is the most widely used and single most useful and rigorous indicator of internal consistency. The TCCA personality profile questionnaire, version 1, revealed an average coefficient alpha of 0.80 with a range of 0.76 to 0.85. That is an acceptable degree of internal consistency.

2.) Questionnaire stability or dependability is the consistency with which a questionnaire measures a variable over time. This is measured on a test - retest protocol in which the questionnaire is used on the same subjects at different times and under different conditions. At 24 days, the coefficient of questionnaire dependability was 0.75 to 0.78. That is an acceptable degree of dependability.

3.) Personality characteristic stability is a measure of the stability of the reification of the abstract personality concepts. At 76 days, the average personality characteristic stability coefficient was 0.74. That is an acceptable coefficient of stability.

Validity: Validity was evaluated by 4 measures: face, construct and convergent/divergent, content, and concurrent criterion validity.

Of the fourteen initial personality characteristics, seven were established as valid by all four criteria. They were:

Anxiety	Fearfulness
Confidence	Risk Taker
Insecurity	Boldness
Restlessness	

The following seven characteristics are in the process of being validated:

Mental Agility	Dominant
Goal Directed	Assertiveness
Decisiveness	Leadership
Self-conscious	

Since only seven of the characteristics have been validated as of this report, only those seven characteristics will be used in the work presented in this report.

Physical Traits:

A list of twelve physical characteristics was developed that, it was thought, might impact the ability to engage in evacuation behaviors. Since this list has been developed for use in experimental, simulated emergency evacuations, some physical traits that might be relevant in emergency evacuations were not included in the list. The list shown here was tailored to the safety concerns of the specific experimental site used for this work. Other sites with different safety concerns and policies may use a more extensive list of relevant physical traits.

The physical traits chosen represent characteristics that could reveal abilities and limitations of the passengers to engage in specific evacuation behaviors. The effect of these physical traits on evacuations could suggest specific physical modifications to the aircraft and/or environment that would improve evacuations.

The physical traits examined in the work reported here include:

Age	% Body Fat
Gender	Waist Flexibility
Handedness	Reflexes
Height	Vision
Weight	Physical Agility
Girth	Artificial Joints

(Other potentially relevant traits were not used in this specific series of experiments in deference to the safety concerns of the experimental site managers.)

To illustrate the potential for evacuation impact of these physical traits, we found, for example, that (1) left handed subjects were twice as likely to have difficulty unlatching their seat belts compared to right handed subjects; and (2) ability to use the evacuation slide easily and appropriately was effected by waist flexibility, height, weight, and gender.

Experiment:

While a great quantity of useful data was collected in a series of simulated emergency evacuations conducted by the Department of Applied Psychology at Cranfield University, this presentation will only focus on a selected set with which to illustrate the concepts proposed by this work.

We found it interesting that when questioned following evacuations, only 3% of the subjects indicated that the cabin crew hindered their evacuation, while 37% indicated that fellow passengers hindered their evacuation. When asked what actions or which passengers made the passengers think that fellow passengers often hindered their evacuation, the most common reason given was the Aseat climbing@ passengers.

We were also surprised to find that, on average, evacuation down the aisle was perceived as almost twice as difficult as evacuation down the emergency slide. In addition, evacuation down the aisle was perceived as more difficult under conditions defined as competitive than those defined as cooperative. When asked what made the aisle evacuation more difficult than slide evacuation, the most common reason given was the frustration of waiting in line and Aseat climbing@ passengers.

When the behavior of subjects was observed under conditions of Acompetitiveness@ and Acooperativeness,@ the subjects perceptions were supported. Although the total time required to

evacuate the aircraft cabin under the two conditions was not statistically significantly different, under Acooperative@ conditions only 7% of subjects climbed over the seats, compared to 18% of subjects under Acompetitive@ conditions. ($p<0.04$)

The most common reason cited by the passengers to explain the increased difficulty of evacuating down the aisle was that Aseat-climbing@ passengers created a bottle-neck when they tried to re-enter the flow of passengers evacuating down the aisle. The perception that bottle-necks occurred when Aseat-climbing@ passengers tried to re-enter the flow of passengers was verified by video. The bottle-necks, according to passengers= perceptions and supported by video resulted in frustration, confusion and irritation.

When the personality traits of the individual passengers that engaged in Aseat-climbing@ were examined, they were found to exhibit a statistically significantly greater degree of Arestlessness@ than their non-seat-climbing cohorts. ($p<0.05$) Therefore, the slow moving flow of passengers in the aisle phase of the evacuation could have had a greater impact on the individuals with a higher degree of restlessness and could have motivated them to take action and do something. One of the few options for action available to them was to climb over the seats in an effort to reduce their frustration and evacuate more rapidly.

When the physical traits of the individual passengers that engaged in Aseat-climbing@ were examined, they were found to have a higher probability of being younger ($p<0.001$), having increased waist flexibility ($p<0.06$), and being male ($p<0.05$).

The dynamics of the behavior by Aseat-climbing@ passengers that resulted in evacuation hindrance can be summarized as follows:

The goal of the subjects was to evacuate as quickly as possible. There was a relatively slow moving flow of passengers down the aisle. The rate of flow frustrated those passengers with a high personality trait for restlessness which that motivated them to seek action or activity. The result was Aseat-climbing@ behavior by those with the requisite physical ability. The Aseat-climbing@ behavior ended with a bottle-neck at the point of re-entry into the passenger flow down the aisle. The consequence was a hindrance at the bottle-neck of the subjects= evacuation plans. The resulting frustration, confusion, and irritation increased the potential for panic and injury. Therefore, Aseat-climbing@ may be an inappropriate evacuation behavior since it is not associated with a faster overall evacuation of the aircraft cabin, but is associated with a decrease in potential safety of the passengers and crew.

If we classify Aseat-climbing@ as inappropriate behavior under the conditions of these experiments as a consequence of its failure to improve evacuation time and its potential to increase panic and injury, it would seem desirable to activate the passengers to other modes of evacuation behavior. Since we cannot realistically re-engineer the human factors, we must examine the aircraft and/or the environmental factors as possible targets for re-engineering.

Conclusions: It might be possible to improve the safety and efficacy of emergency aircraft cabin evacuations by evaluating the human factors aspects of evacuation behavior. The results of the evaluations could be used to re-engineer aircraft and environmental factors to activate passengers to appropriate and beneficial behavior.

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